AC 2009-2364: ENHANCING K-12 SCIENCE AND ENGINEERING THROUGH SUSTAINABLE PARTNERSHIPS BETWEEN SCIENTISTS AND TEACHERS

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Overview, History and Mission

The ______Classroom Connection (XXX) is a science education outreach program building 1-to-1 partnerships between _____scientists and local area elementary, middle, and high school teachers. The XXX began in 2002 with one graduate student brainstorming with _____ staff and several science teachers about outreach programs and teachers needs. The program has been subsequently refined by further scientist-volunteer and teacher feedback, as well as administrative feedback at the campus- and school district-level. Initially, graduate students led the grassroots effort to invest in sustainable (year-long) partnerships that mutually benefited the K-12 classrooms, teachers, and scientist volunteers.

The conceptual model originally developed was to provide graduate students with teaching and outreach experiences, K-12 teachers with a scientific resource, and an entire classroom with scientific exposure and mentorship. In the beginning, XXX events were supported under the umbrella of established NSF Centers (_______) that received outreach support. Additional support from other ______ outreach efforts helped recruit the first teachers for feedback and XXX Partnerships. Further funding was received from foundations (____Foundation) and _____ campus funds (_____ Fund). These funds provided several thousand dollars to support small classroom grants for each XXX Partnership. The grants pay for classroom equipment or fieldtrips to supplement classroom science experiences designed by teachers and scientists.

As the XXX became established on campus, faculty began requesting partnerships to support the proposed outreach efforts for their grants, and postdoctoral scholars as well as staff sought educational and outreach opportunities. Through a partnership with _____ faculty applying for a Research Center, the XXX received four-year support from the Howard Hughes Medical Institute (HHMI) to hire a part-time coordinator, expand the program, and create summer lab research opportunities at ______ for high school students.

HHMI funding also provides travel support for XXX directors to learn from other outreach centers and disseminate our work at conferences, and support for program evaluation to explore ways to improve the program and document its effects on participants. This paper describes our partnership model, findings from the 2008 formative evaluation, and plans for improvement.

Community Diversity

The XXX community of volunteer scientists, teachers, and students has a diverse range of teaching and educational opportunities and needs. The ____ School District (XXXX) and other local schools serve a diverse population that includes groups typically underrepresented in science and engineering (Table 1) and that vary widely in classroom needs. Teachers represent the full spectrum of grades K-12, both genders about equally, and a broad range of experience from fairly novice to veteran teachers. Scientist-volunteers include graduate students, post docs, and occasionally staff or alumni, and they vary in the grade-level, subject area, and classroom role in which they are interested. XXX collaborations are adjusted by each set of partners to serve the individual needs of the students, teachers, and volunteers. XXX Volunteers have assisted teachers with labs, group work, and class discussions, as well as provided classroom guest lectures, enhanced curricula with extended or new activities, developed labs, lectured, conducted demonstrations and led field trips to ______, local science museums and other locations.

School Name, Unified School	Hispanic / Latino	African American	White	Asian	Free or Reduced Lunch
School J, High School	64%	34%	4%	<1%	60%
School P High School	51%	23%	20%	3%	48%
School B, High School	53%	31%	11%	2%	53%
School M, High School	59%	18%	16%	3%	65%
School J, Middle School	35%	<1%	7%	53%	58%
School D High School	74%	24%	1%	<1%	100%
School M Elementary School	42%	22%	21%	11%	52%
School P Elementary School	87%	2%	8%	<1%	72%
School L, High School	64%	1%	16%	<1%	
School G High School	25%	4%	55%	<1%	

Table 1. Local-area Schools with _____ Classroom Connection (XXX) Partnerships: School Names are listed with demographic breakdown, and student percentage qualifying for free or reduced lunch (http://www.greatschools.net)

Volunteer Recruitment and Screening

The ability to recruit science-volunteers from a variety of fields and with sufficient time to commit to the program is integral to the success of the XXX. ____ volunteer recruitment consists of campus activity fairs, campus billboard postings, e-mails to other outreach groups, alumni networks, the _____ website, and past volunteers. As a prerequisite for acceptance, volunteers attend one of several XXX information sessions or meet individually with a XXX Co-Director. At these sessions, co-directors give potential volunteers an overview of the XXX and outline the opportunities and the commitments expected. Returning volunteers are given pairing preference, and some returning volunteers are recruited to the administrative role of co-director.

Teacher Recruitment and Screening

Equally important to the success of the XXX is recruitment of a diverse group of committed teachers willing to collaborate with a scientist and to try some new things in their classrooms. Successful teachers from previous years are invited to return to the program and asked to refer motivated and interested colleagues. In addition, XXX Co-Directors provide presentations at local schools coordinated by lead teachers, science chairs, district volunteer liaisons, or principals. Teacher responses to a feedback form help identify which teachers can make time to collaborate with a scientist-volunteer, who has experience with science or hosting volunteers, and where acute needs exist. Recommended and interested teachers are asked to fill out a teacher background questionnaire, and their acceptance into the program is based on their timely return of a questionnaire along with their experience, and interests. Table 2 provides a breakdown of subject areas, grade levels, class sizes, and volunteers for XXX Teacher during the 2007-08 academic year.

School Name, Unified School District (USD) or City	**Subject (Grade)**	**Teachers**	**Volunteers**	**Classrooms**	**Class Size**
School J High School	Physics (11th), Biotechnology (11th), Biology (9th) Social Science (11th)	1 1 1 1	1 1 2 1	1 1 1 1	25[a] 25 30 30
School P High School	Mathematics (11th) Chemistry (11th) Physics (10th)	1 1 1	1 1 2	1 1 3	26 15 60
School B High School	Physics (11th)	1	1	1	38[b]
School M High School	Mathematics (11th)	1	1	1	36
School J Middle School	Earth Science (6th)	1	1	1	30
School S Middle School	Life Science (7th)	1	1	1	36[c]
School D High School	Computer Programming (12th)	1	1	1	20
School M Elementary School	General Science (3rd)	4	4	4	92[d]
School P Elementary School	Science (Kindergarten)	1	1	1	20
School L High School	Physics (11th)	1	1	1	25
School G High School	Physics (11th)	1	2	3	90
Total		**19**	**22**	**23**	**598**

Table 2. ______ Classroom Connection (XXX) School Partnership Overview: 16 of 18 Classroom Partnerships were within public unified school districts (USD). Class subjects and grade levels are listed next to the classrooms with XXX Science-Teacher Partnerships, and K-12 Class Size.

[a] Approximately 50 students from local area high schools participated in the XXX Hosted, 'Opportunities for You in Science and Engineering conference.'

[b] Students also experienced a Faculty Presentation

[c] 105 Seventh grade students and two teachers also experienced the ________ Laboratory

[d] 120 Students also visited the ______ Science Center; 60 students and 6 teachers were provided a guided ____ Lab experience concerning the physics and engineering of sailing.

Pairings Meetings (Scientist-Teacher)

After the XXX partnerships are formed based on the teachers' and volunteers' responses to questionnaires about subject of specialty/need, schedule availability, and collaboration vision, along with past teacher' XXX experiences. An initial meeting, or Pairing Meeting, facilitated by XXX Co-Directors, is held for each of the scientist-teacher collaborations. During this meeting the teachers describe their classes, the classroom dynamics, and syllabus or pacing guide. Volunteers discuss their educational background, research interests, and which class schedule or student dynamic would best fit. Meeting outcomes include: a scheduled first visit to introduce the volunteer to the classroom and teachers system, how often they will interact with the targeted classroom (from once per week, to once per month), initial ideas how the volunteer(s) will collaborate with the teacher and their classroom, the best form of communication, and the latest district volunteer guidelines.

Creating Sustainable Partnerships

Creating XXX partnerships brings together two distinct groups, teachers and scientists, who come from different "cultures" in their work (research academia versus public schools), with limited time to devote to the partnership, a required curriculum and standards to accommodate, and with both shared and unique goals and talents. They also may not appreciate how their own talents and expertise could benefit their partner. Critical characteristics of successful XXX Partnerships include frequent and clear scientist-teacher communication and realistic and shared expectations. Adjustments to each partnership are inevitable, so it is beneficial to help partners become comfortable discussing their ideas as challenges occur. Scientists, even when they have prior educational outreach experience, may find choosing their classroom role or designing a lab/curricula challenging. We recommend the scientist-volunteers initially shadow the teacher to become familiar with their science curriculum, appreciate what it may take to engage the class, how much material is covered in a period, and the scope of students' interests. Teachers may also initially find it challenging to work collaboratively with scientist-volunteers, express their classroom needs, and appreciate the expertise that they have that would benefit scientist volunteers, such as techniques for engaging and assessing students.

Supporting Collaborations

Periodic meetings throughout the year serve a variety of purposes to help support partnerships. On-campus meetings with only scientist-volunteers present provide good forums for sharing experiences among new and experienced volunteers as well as discussions of literature on science education or workshops related to educational topics of interest such as motivation of students. Likewise, meetings with only teachers present can provide a collaborative environment for sharing ways they engage students, provide feedback to their scientist volunteer on his/her teaching, and see evidence of program impact on their students. Finally, meetings with both scientists and teachers provide an opportunity to share partnership experiences, discover needs and share resources, and build networks.

Our _____'s other outreach efforts have helped us share resources to address common needs. For example, we have partnered with education specialists to provide campus seminars on outreach topics and facilitate discussion of ideas from research on science education, and we have partnered with outreach centers to organize more campus touring opportunities for classrooms. With the support of other centers, larger and more enriching tours can be held that involve hands on activities, college related preparation lectures, and scientific lectures.

Formative evaluation efforts also support and shape the program. The XXX model and our procedures have been revised slightly each year based on program directors' experiences, their observations of meetings and classrooms, and survey data collected from all participants about the value of being involved in the XXX, partnership satisfaction, and perceived impact on teachers, scientists and students. The findings below reflect survey data from 14 of 18 teachers and 19 of 21 volunteers who participated in the XXX program during the 2007-08 academic year. Surveys including 5-point Likert scale items and open-ended questions were administered in spring of 2008. The results are summarized below, incorporating both teachers' and volunteers' perspectives. Table 3 lists Teacher and Volunteer mean ratings for key items.

Partnership Data and Goals

Most volunteers visited their teacher-partner's classroom at least 10 times (although it ranged from a few to over 15 times), spending 1-3 hours in the class and 1-2 hours in preparation for each visit. Thus teachers and students each had approximately 20 hours of time with a scientist on average, and each scientist volunteered about 35 hours over the course of the year. The number, timing, and nature of class visits were worked out between partners to suit students' and teachers' needs, and everyone's interests and schedules.

<u>Teachers</u> were quite positive about their partnerships with scientist-volunteers (average ratings over 5 items were 4.29-4.71 on a 1-5 scale where 5=agree very much). Their highest rated item was on recommending the program to other teachers, and they also tended to want to be in the program again. Teachers generally felt reasonably well matched to their volunteer, but three gave ratings of only "2" or "3," indicating some room for improvement. Explanations for these ratings include overestimation of free time available for scientist-volunteers to commit to the program, poor alignment of graduate student expertise with course subject, and different expectations for classroom roles (for example, lecturer versus small group mentor).

Table 3. V and T survey responses

	T	V
Partnership		
recommend XXX to others	4.71	4.89
partner a good match for me	4.29	4.16
partner dependable, met expectations	4.43	3.94
satisfied w/ amt/qual communication w/ partner	4.50	4.11
want to be in XXX again	4.36	4.33
V was good match for students & course	na	3.95
V got useful feedback from T	na	3.79
T had reasonable expections for V role & prep	na	4.39
Impact on Students		
V helped students comprehend new ideas	4.29	3.74
V increased student interest in science	4.36	4.05
Students improved perceptions of science	4.57	4.00
V a good role model for students	4.64	na
Students got better idea of what S/E entail	4.50	na
Impact on Volunteers		
worthwhile experience	na	4.47
satisfied w/ time put in	na	3.58
got useful feedback from teacher	na	3.79
learned useful info about teaching	na	3.74
enjoyed work in and out of class	na	4.42

Volunteers' perspective on the partnerships generally echoed that of the teachers. The average ratings on 8 "partnership" items ranged from 3.79 to 4.89. Like teachers, volunteers gave a very high rating to recommending the program to others and a high rating to wanting to be in the program in future. They also tended to feel fairly well matched to their teachers (mean=4.16) and students and courses (mean=3.95). Those who were less positive made comments such as they might have better suited to an advanced placement class, poor class discipline was frustrating, or that students were "not very receptive to learning anything outside of the course material." These data have led us to plan teacher and volunteer workshops that include strategies for motivating students. Volunteers also were fairly satisfied with their teacher-partner's dependability and communications (although volunteers were slightly less positive than teachers in this regard). Volunteers' were least satisfied with the amount of useful feedback on their own teaching skills that they obtained from teachers (mean =3.79). We plan to make it more clear to teachers that volunteers desire to have teachers' help in developing their instructional abilities and to brainstorm with teachers some strategies for their sharing constructive feedback with their partners. Since teachers rarely critique each others' skills, many of them may have little experience in this area.

Impact on Students

Teachers were quite positive about the program's effects on students (average rating over the 6 items was 4.45). They were particularly positive about the volunteers being good role models for their students and improving students' interest in and perceptions of scientists and their work, with comments like the following:

- Any time I mentioned he was coming or that we were going to do a lab, my students would shout out their excitement. Many truly bonded with my volunteer. It really made their day when he showed up for their promotion.
- When I ask my students at the end of third grade what they might like to do when they grow up, many of them write that they would like to become scientists (even if they can't spell the word correctly.)
- He was intelligent, hard working, and easy going. The more laid back students related to him and the hard working students did too.
- The impact of seeing a highly intelligent individual who looked just like them had a HUGE effect.
- Having two women speak and teach in my all girls' science class and do interesting activities was really good for the girls. They were ALL respectful, engaged, and interested when the volunteers came to class.
- The visits to the lab and ______ really brought a connection to real world scientists for my students.
- Showing students the wonders that come from mathematics is EXTREMELY necessary. Most students see higher math courses as unnecessary, unrelated to anything, and torturous. My volunteer let them see many examples of math in action.
- My AP students enjoyed hearing about her experiences as a first year grad student.
- One of my better students said she will apply to _________ because she thinks she can handle it now.

Teachers also felt the volunteers helped students understand scientific ideas and methods, as these comments show:

- My students get very excited about meeting a Real Scientist! Their enthusiasm generates great questions and on-going investigations.
- She taught them [elementary students] things that they could do at home, such as making bubbles or showing evaporation
- My volunteer worked with small groups of [high school] students, three or four, pulled out to the library to work on reviewing misconceptions or missed items on assessments. Having someone to provide that support to small groups of students within the school day was beneficial. If we were more systematic it could have been even more effective.
- He made an excellent presentation on practical networks that really made sense to the (computer programming) class.

Volunteers were also positive, but slightly less so than teachers, in their ratings about the effects of the program on students, probably reflecting the limited evidence they have from the relatively little time they spend with students. Their comments, however, tended to mention the same outcomes that teachers noted, including new understanding of content and the nature of science, increased confidence and motivation to study science, and appreciation for how their studies link to real science and the larger world. We plan to expand future volunteer meetings to discuss evidence of the program's impact on students as well as other topics.

Impact on Teachers

When asked what impact the program had on themselves, teachers cited new content knowledge, help in teaching and motivating their students, inspiration and ideas for teaching science well in future, new resource networks and friendships with other teachers and volunteers, new respect for ______, and appreciation for its contribution to the community. Volunteers also noted several of these.

Impact on Volunteers

As indicated by their eagerness to participate again and to recommend the program to others, volunteers were quite positive about the program in their comments. Overall, they felt it was a very worthwhile experience and enjoyed it a lot. Many wished they had been able to contribute more time to it. They were only somewhat positive about the extent to which they learned useful information about teaching and received helpful feedback from their teacher-partners, as already noted.

Program Administration

Teachers were extremely positive about XXX's administrative support. However, only some utilized their classroom stipends of several hundred dollars. To inspire and motivate more teachers to use their stipends, we plan to share a list of past purchases and approximate costs of science related trips, along with cautions to plan purchases early to obtain equipment in time for scheduled use.

Current Program Goals

Each partnership seems to have been a unique creation of its particular teacher and volunteer, most of which worked quite well. However, future partnerships could benefit from learning more about what others have done before them along with the pros and cons of these various approaches. The following additional ideas were suggested by teachers for improving the program:

- Select volunteers who can truly make the time commitment (most did well but a few underestimated the demands of graduate school)
- Train volunteers how to present material to students like those with whom they will be working; perhaps they can observe some classrooms before deciding what sort of class they would like to work with.

- Start in the early fall so it is easier for teachers to integrate new plans into their curriculum. Many schools begin in August, so planning could be done at the end of previous year and/or summer
- Clarify the process for accessing funds, encourage timely planning for funds, share sources for discounted equipment/supplies, and share ideas for how to use the funds (field trips, supplies, and demonstrations were most common this year)
- Add a tutorial component to help students with school work

Additional areas for improvement were derived from volunteers' comments:

- Help teachers realize that part of their obligation in the program is to help the volunteers learn or hone their teaching skills; some training could be added to help teachers learn to provide useful feedback to volunteers.
- Help both partners be more efficient by supplying examples of what others have done and "lessons learned."

The key to a successful and sustainable partnership program is establishing partnerships that both teachers and scientist-volunteers view as feasible and mutually beneficial. Formative evaluation data from participants help us identify what works and where improvements or new strategies are needed. For example, the data discussed suggested new meeting and training topics for this year, including more effective feedback for volunteers, early clarification of partnership expectations, and training in new strategies for student engagement. During this year we are extending our data collection to include interviews with teachers and volunteers to follow up in greater detail on topics that emerged in last year's surveys. In addition, we are beginning to extend the XXX program in a new direction by building on our network of experienced XXX teachers and scientist volunteers to create new educational and mentorship opportunities in the form of on-campus laboratory research opportunities for students and teachers, a small version of which we piloted this past summer with considerable success.